

TRANSPORTATION RESEARCH
CIRCULAR

Number E-C166

August 2012

**Glossary of
Regional Transportation
Systems Management and
Operations Terms**

Second Edition

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

**TRANSPORTATION RESEARCH BOARD
2012 EXECUTIVE COMMITTEE OFFICERS**

Chair: Sandra Rosenbloom, Professor of Planning, University of Arizona, Tucson
Division Chair for NRC Oversight: C. Michael Walton, Ernest H. Cockrell Centennial Chair in Engineering, University of Texas, Austin
Executive Director: Robert E. Skinner, Jr., Transportation Research Board
Vice Chair: Deborah H. Butler, Executive Vice President, Planning, and CIO, Norfolk Southern Corporation, Norfolk, Virginia

**TRANSPORTATION RESEARCH BOARD
2012–2013 TECHNICAL ACTIVITIES COUNCIL**

Chair: Katherine F. Turnbull, Executive Associate Director, Texas Transportation Institute, Texas A&M University, College Station
Technical Activities Director: Mark R. Norman, Transportation Research Board

Paul Carlson, Research Engineer, Texas Transportation Institute, Texas A&M University, College Station, *Operations and Maintenance Group Chair*

Thomas J. Kazmierowski, Manager, Materials Engineering and Research Office, Ontario Ministry of Transportation, Toronto, Canada, *Design and Construction Group Chair*

Ronald R. Knipling, Principal, safetyforthelonghaul.com, Arlington, Virginia, *System Users Group Chair*

Mark S. Kross, Consultant, Jefferson City, Missouri, *Planning and Environment Group Chair*

Peter B. Mandle, Director, LeighFisher, Inc., Burlingame, California, *Aviation Group Chair*

Harold R. (Skip) Paul, Director, Louisiana Transportation Research Center, Louisiana Department of Transportation and Development, Baton Rouge, *State DOT Representative*

Anthony D. Perl, Professor of Political Science and Urban Studies and Director, Urban Studies Program, Simon Fraser University, Vancouver, British Columbia, Canada, *Rail Group Chair*

Steven Silkunas, Director of Business Development, Southeastern Pennsylvania Transportation Authority, Philadelphia, Pennsylvania, *Public Transportation Group Chair*

Peter F. Swan, Associate Professor of Logistics and Operations Management, Pennsylvania State, Harrisburg, Middletown, Pennsylvania, *Freight Systems Group Chair*

James S. Thiel, General Counsel, Wisconsin Department of Transportation, *Legal Resources Group Chair*

Thomas H. Wakeman, Research Professor, Stevens Institute of Technology, Hoboken, New Jersey, *Marine Group Chair*

Johanna P. Zmud, Director, Transportation, Space, and Technology Program, RAND Corporation, Arlington, Virginia, *Policy and Organization Group Chair*

TRANSPORTATION RESEARCH CIRCULAR E-C166

Glossary of Regional Transportation Systems Management and Operations Terms

SECOND EDITION

Prepared by
Louis G. Neudorff
John Mason
and
Jocelyn Bauer

for the
Regional Transportation Systems Management and Operations Committee
Transportation Research Board

August 2012

**Transportation Research Board
500 Fifth Street, NW
Washington, DC 20001
www.TRB.org**

The **Transportation Research Board** is one of six major divisions of the National Research Council, which serves as an independent advisor to the federal government and others on scientific and technical questions of national importance. The National Research Council is jointly administered by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal.

The **Transportation Research Board** is distributing this Circular to make the information contained herein available for use by individual practitioners in state and local transportation agencies, researchers in academic institutions, and other members of the transportation research community. The information in this circular was taken directly from the submission of the authors. This document is not a report of the National Research Council or the National Academy of Sciences.

Operations and Preservation Group

Paul J. Carlson, *Chair*

Operations Section

Peter M. Briglia, Jr., *Chair*

Regional Transportation Systems Management and Operation Committee

Leslie N. Jacobson, *Chair*

Walter H. Kraft, *Immediate Past Chair*

Haitham M. Al-Deek
Jocelyn K. Bauer
Wayne Berman*
J. Thomas Bruff
Lisa Burgess
Philip M. Charles
Eddie James Curtis, Jr.
Travis P. Dunn
Richard B. Easley
Matthew L. Edelman
Thomas George

Stephen W. Glascock
Diana L. Gomez
Michael J. Harris
James R. Hogan
Thomas H. Jacobs
Randy J. Knapick
Steven Z. Levine
Virginia Rose Lingham
Keith A. McCabe
Peter T. McCombs

Catherine C. McGhee
Louis G. Neudorff
Douglas E. Noble
Patricia B. Noyes
Wenjing Pu
Eileen M. G. Singleton
Robert J. Taylor
Valentin G. Vulov
Leon Ming Wei Wee
Thomas C. Werner
Robert M. Winick

* Emeritus

TRB Staff

Richard A. Cunard, *Traffic and Operations Engineer*

Freda R. Morgan, *Senior Program Associate*

Transportation Research Board
500 Fifth Street, NW
Washington, D. C.
www.TRB.org

Contents

Foreword	1
Glossary	2
Access Management—Capacity	2
Clarus—Connected Vehicle	4
Context-Sensitive Solutions—Financially Constrained	6
First Responder—Incident Management	8
Integration—Junction Control	10
Livability—Metropolitan Transportation Plan	12
Mileage-Based User Fee—Operational Concept	14
Operational Integration—Planning Factors	16
Planning for Operations—Regional Concept for Transportation Operations	18
Regional ITS Architecture—State Transportation Improvement Program	20
Sustainable Transportation—Transit Signal Priority	22
Transportation Asset Management—Variable Speed Displays	24
Vision—Work Zone Management	26
References	27

Foreword

This glossary is an update of a previous edition published in April 2009 as *Transportation Research Circular E-C133: Glossary of Regional Transportation Systems Management and Operations Terms*. The goal is to avoid the frequently occurring misconceptions that arise through the use of different terms for the same meaning.

This glossary was developed by professionals in the transportation community for fellow professionals and those who work with them in improving the management and operations of our transportation systems. An editorial committee including Louis G. Neudorff, Chair; Les Jacobson; Walter H. Kraft; Beverly Kuhn; Phil Masters; and Robert Sheehan guided the development of the glossary.

Comments on the manuscript were received and incorporated from Jocelyn Bauer, Dan Baxter, Wayne Berman, Richard Dowling, Michael Haas, James Hunt, Thomas Jacobs, Keith McCabe, Egan Smith, Robert Taylor, Thomas Werner, and Kristine M. Williams.

John Mason developed the initial draft for the TRB Regional Transportation Systems Management and Operations Committee. As chair of the editorial committee, Neudorff guided the document through updates, the review process, and final editing. The efforts of these authors and the reviewers are appreciated and acknowledged.

This glossary should be viewed as a starting point, not as a final product. It is presented as a living document that will undergo periodic reviews and updates to stay abreast of the changes in the management and operations of our transportation systems.

—Walter H. Kraft, *Immediate Past Chair*
Regional Transportation Systems Management and Operation Committee

Glossary of Regional Transportation Systems Management and Operations Terms

Access Management The systematic control of the location, spacing, design, and operation of driveways, median openings, interchanges, and street connections to a roadway as well as roadway design applications that affect access, such as median treatments and auxiliary lanes, and the appropriate separation of traffic signals (1).

Accessibility The ease of reaching valued destinations, such as jobs, shops, schools, entertainment, and recreation (2).

Active Traffic Management (ATM) The ability to dynamically manage recurrent and non-recurrent congestion on the main line based on prevailing traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility. It increases throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without delay, that occurs when operators must deploy operational strategies manually (3).

ATM, also referred to managed motorways in the United Kingdom, can be combined with travel demand management (refer to definition) and other operational strategies to create active transportation and demand management (ATDM). Refer to the ATDM definition following, as well as to definitions for the various ATM strategies (e.g., variable speed displays, dynamic lane assignment, hard shoulder running, junction control, and queue warning).

Active Transportation and Demand Management (ATDM) The collective approach for dynamically managing travel and traffic demand and available capacity of transportation facilities, based on prevailing traffic conditions, using one or a combination of operational strategies that are tailored to real time and predicted conditions in an integrated fashion (5).

ATDM implies an approach for dynamically managing and controlling traffic demand and available capacity of transportation facilities, based on prevailing traffic conditions, using one or a combination of real time and predictive operational strategies. When implemented together and alongside traditional traffic demand management strategies, these operational strategies help to maximize the effectiveness and efficiency of the transportation facility and result in improved safety, trip reliability, and throughput. A truly active management philosophy dictates that the full range of available operational strategies be considered, including the various ways these strategies can be integrated together and among existing infrastructure, to actively manage the transportation system so as to achieve system performance goals. This includes traditional traffic management and intelligent transportation system (ITS) technologies as well as new technologies and non-traditional traffic management technologies used outside of the United States (4).

Several of the potential operational strategies that may be combined and integrated into an ATDM-based approach are defined in this glossary, including active traffic management, managed lanes, ramp management, travel demand management, and integrated corridor management among others.

Adaptation Strategies and organizational responses to protect or adapt systems so as to reduce the risks and moderate the potential harm from and exploit the beneficial opportunities of the impacts of climate change.

On the basis of current knowledge, climate scientists have identified five climate changes of particular importance to transportation, including increases in very hot days and heat waves, increases in Arctic temperatures, rising sea levels, increases in intense precipitation events, and increases in hurricane intensity. As climate changes induce new extremes, operational responses are likely to become more routine and proactive than today's approach of treating severe weather on an ad hoc, emergency basis (5).

Attainment Area Any geographic area in which levels of a given criteria air pollutant (e.g., ozone, monoxide, PM₁₀, PM_{2.5}, and nitrogen dioxide) meet the health-based National Ambient Air Quality Standards (NAAQS) for that pollutant (see also Nonattainment Area) (23 CFR 450.104).

Bus Rapid Transit (BRT) A bus system that operates on bus lanes or other transitways in order to combine the flexibility of buses with the efficiency of rail.

A bus lane is a traffic lane on a surface street reserved for the exclusive use of buses. A busway is a special roadway designed for the exclusive use of buses. A busway can be in its own right-of-way, or in a railway or highway right-of-way. BRT operates at faster speeds, provides greater service reliability, and increased customer convenience. It also utilizes a combination of advanced technologies, infrastructure, and operational investments that provide significantly better service than traditional bus service (6).

BRT is an innovative, high-capacity, lower-cost public transit solution that can significantly improve urban mobility. This permanent, integrated system uses buses or specialized vehicles on roadways or dedicated lanes to quickly and efficiently transport passengers to their destinations, while offering the flexibility to meet transit demand. BRT systems can easily be customized to community needs and incorporate state-of-the-art, low-cost technologies that result in more passengers and less congestion (7).

Capacity A transportation facility's ability to accommodate a moving stream of people or vehicles in a given time period, under prevailing conditions (e.g., infrastructure, traffic, control) (8). (Note: Added "under prevailing conditions ..." to provide consistency with the *Highway Capacity Manual*.)

The *Highway Capacity Manual* defines capacity as the maximum sustainable flow rate at which vehicles or persons reasonably can be expected to traverse a point or uniform segment of a lane or roadway during a specified time periods under given roadway conditions, geometric, traffic, environmental, and control conditions; usually expressed in vehicles per hour, passenger cars per hour, or persons per hour.

The *Transit Capacity and Quality of Service Manual* (9) defines capacity (achievable) as the maximum number of passengers that can be transported over a given section of a transit line in one direction during a given time period, factored down to reflect the uneven passenger demand during the peak hour, uneven vehicle occupancy and, for rail, the uneven loading of cars within a train. Usually the maximum capacity with unlimited vehicles, if constrained by number of vehicles this must be clearly stated.

Clarus A research and development initiative established by the FHWA Road Weather Management Program, in conjunction with the Intelligent Transportation Systems (ITS) Joint Program Office, to reduce the impact of adverse weather conditions on surface transportation users. The goal of *Clarus* (Latin for clear) is to demonstrate and evaluate the value of “Anytime, Anywhere Road Weather Information” that is provided by both public agencies and the private weather enterprise to the breadth of transportation users and operators (10). See also Road Weather Management.

Collaboration Any cooperative effort between and among governmental entities (as well as with private partners) through which the partners work together to achieve common goals.

Such collaboration can range from very informal, ad hoc activities to more planned, organized, and formal ways of working together. The collaborative parties work toward mutual advantage and common goals. They share a sense of common purpose, leverage resources to yield improved outcomes, and bridge traditional geographic, institutional, and functional boundaries (11). (Note: Replaced the term “public purpose” with “common purpose” to indicate that collaboration involves more than just public agencies.)

Collaboration should go beyond solving a problem. Its purpose should be that of combining the knowledge, expertise, and information of many agencies across jurisdictions to produce and operate an efficient regional transportation system (12).

Concept of Operations A formal document that provides a user-oriented view of a proposed new system (or regional operations program) (13). Also refer to Operational Concept.

The Concept of Operations documents the total environment and use of the system to be developed in a nontechnical and easy-to-understand manner; presents this information from multiple viewpoints; and provides a bridge from the problem space and stakeholder needs to the system-level requirements

The Concept of Operations document results from a stakeholder view of the operations of the system being developed. This document will present each of the multiple views of the system corresponding to the various stakeholders. These stakeholders include operators, users, owners, developers, maintenance, and management. This document can be easily reviewed by the stakeholders to get their agreement on the system description. It also provides the basis for user requirements (14).

Conformity A Clean Air Act [42 U.S.C. 7506(c)] requirement that ensures that federal funding and approval are given to transportation plans, programs, and projects that are consistent with the air quality goals established by a state implementation plan (SIP).

Conformity, to the purpose of the SIP, means that transportation activities will not cause new air quality violations, worsen existing violations, or delay timely attainment of the NAAQS. The transportation conformity rule (40 CFR part 93) sets forth policy, criteria, and procedures for demonstrating and assuring conformity of transportation activities. (23 CFR 450.104.)

Congestion Congestion is travel time or delay in excess of that normally incurred under light or free-flow travel conditions (15)

Congestion is often classified as either recurrent or nonrecurrent. The type of congestion depends on whether the capacity or the demand factor is out of balance.

- *Recurrent congestion* results when demand increases beyond the available capacity. It usually is associated with the morning and afternoon work commutes, when demand reaches such a level that the freeway is overwhelmed and traffic flow deteriorates to unstable stop-and-go conditions.

- *Nonrecurrent congestion* results from a decrease in capacity, while the demand remains the same. This kind of congestion usually results when one or more lanes are temporarily blocked due to a crash, disabled vehicle, weather events, etc. (16).

Congestion Management Process (CMP) A systematic and regionally accepted approach for managing congestion that provides accurate, up-to-date information on transportation system performance and assesses alternative strategies for congestion management that meet state and local needs. The CMP is intended to move these congestion management strategies into the funding and implementation stages (17).

Congestion Management System (CMS) A systematic and regionally accepted approach for managing congestion that provides accurate, up-to-date information on transportation system operations and performance and assesses alternative strategies for congestion management that meet state and local needs (23 CFR 500.109).

Through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), the CMS has been replaced by the CMP. According to SAFETEA-LU, under certain conditions the CMS may constitute the CMP [23 USC 135 (i)].

Congestion Pricing A system of surcharging users of a roadway network during periods of peak demand to reduce congestion.

Congestion pricing, sometimes called value pricing, is a way of harnessing the power of the market to reduce the waste associated with traffic congestion. There are four main types of pricing strategies (18):

- Variably priced lanes involving variable tolls on separated lanes within a highway, such as express toll lanes or high occupancy toll (HOT) lanes.
- Variable tolls on entire roadways, both on toll roads and bridges, as well as on existing toll-free facilities during rush hours.
- Cordon charges are either variable or fixed charges to drive within or into an area within a city.
- Areawide charges are per-mile charges on all roads within an area that may vary by level of congestion.

Connected Vehicle A research program—sponsored by the U.S. Department of Transportation’s Research and Innovative Technology Administration and others—focusing on the development and deployment of a fully connected transportation system that makes the most of multimodal, transformational applications addressing safety, mobility, and the environment (19).

- *Connected vehicle safety applications* are designed to increase situational awareness and reduce or eliminate crashes through vehicle-to-vehicle and vehicle-to-infrastructure data

transmission that supports driver advisories, driver warnings, and vehicle or infrastructure controls.

- *Connected vehicle mobility applications* provide a connected, data-rich travel environment. The network captures real-time data from equipment located onboard vehicles (automobiles, trucks, and buses) and within the infrastructure. The data are transmitted wirelessly and are used by transportation managers in a wide range of dynamic, multimodal applications to manage the transportation system for optimum performance.
- *Connected vehicle environmental applications* both generate and capture environmentally relevant real-time transportation data and use this data to create actionable information to support and facilitate green transportation choices. They also assist system users and operators with green transportation alternatives or options, thus reducing the environmental impacts of each trip. Onboard equipment may also advise vehicle owners on how to optimize the vehicle's operation and maintenance for maximum fuel efficiency. The AERIS (Applications for the Environment: Real-Time Information Systems) program was initiated to investigate whether it is possible and feasible to generate or capture environmentally relevant real-time transportation data from vehicles and the system and how this data may be used.

Context-Sensitive Solutions (CSS) A collaborative, interdisciplinary, and holistic approach to the development of transportation projects. It is both process and product, characterized by a number of attributes. It involves all stakeholders, including community members, elected officials, interest groups, and affected local, state, and federal agencies. It puts project needs and both agency and community values on a level playing field and considers all trade-offs in decision making.

At the heart of the CSS approach is the methodical integration of diverse values at each step of the process. The process considers a range of goals that extends beyond the transportation problem. It includes goals related to community livability and sustainability, and seeks to identify and evaluate diverse objectives earlier in the process and with greater participation by those affected. The result is greater consensus and a streamlined project during later stages of project development and delivery (20).

Corridor A broad geographical band that follows a general directional flow connecting major sources of trips that may contain a number of streets, highways, and transit route alignments (9).

A largely linear geographic band defined by existing and forecasted travel patterns involving both people and goods, the corridor serves a particular travel market or markets that are affected by similar transportation needs and mobility issues. The corridor includes various networks [e.g., limited access facility, surface arterials, transit (rail and bus), bicycle, pedestrian pathway, and waterway] that provide similar or complementary transportation functions. Additionally, the corridor includes cross-network connections that permit the individual networks to be readily accessible from each other (21).

Data Archiving The systematic retention and re-use of transportation data that is typically collected to fulfill real-time transportation operation and management needs. Data archiving is also referred to as data warehousing or operations data archiving. Transportation operations and their respective sensors and detectors, and other data collection processes, are a potentially rich and detailed source of data about transportation system performance and characteristics (22).

(Note: Inserted the phrase “and other data collection processes” to address private-sector data collection.)

Designing for Operations The combination of policies, procedures, and strategies that support the needs of transportation management and operations within transportation project design and development processes.

Designing for Operations supports the mainstreaming of operational considerations in infrastructure design and maintenance activities and complements Planning for Operations by institutionalizing management and operations further in the project development process and providing additional emphasis on the day-to-day requirements of transportation system operators (from U.S. Department of Transportation).

Dynamic Lane Assignment (DLA) The use of lane control signals to provide advance notice that a lane is closed ahead and to start the merge process into the available lanes well in advance of the actual closure.

DLA is often installed in conjunction with variable speed displays (refer to definition in this glossary). DLA also supports the ATM strategies of hard shoulder running, queue warning, and junction control (4).

Dynamic Rerouting The use of variable destination signing to make better use of available roadway capacity by directing motorists to less-congested facilities.

Dynamic rerouting signs are often intended for the non-local traveler wishing to travel through a metropolitan area. As a result, dynamic routing is often used to divert traffic around central business districts or other activity centers and most effectively applied to Interstate corridors (4).

Emergency Management Also known as Emergency Transportation Operations (ETO). The process of preventing, preparing, responding, and recovering from an emergency, where an emergency is an unexpected, or no-notice, large-scale, damaging event.

When an emergency has occurred (or the imminent threat of one has become known), ETO focuses on minimizing the time it takes to get an adequate force of emergency responders to the scene where they can help victims, provide assessments, and control access and maximize the proportion of the population moved away from the hazardous area without being subjected to other risks (23).

Event An occurrence, which includes all types of incidents, emergencies, and disasters (natural or human caused), that affects the transportation system and requires actions to maintain the safety and mobility of the system (24).

Express Toll Lanes (ETL) A lane pricing strategy similar HOT lanes, except that all vehicles are charged a toll to use the lane. These facilities are essentially access restricted toll roads with limited access implemented within the freeway right-of-way and that are actively managed to preserve free-flow operating conditions (25).

Financially Constrained or Fiscal Constraint The metropolitan transportation plan, transportation improvement plan (TIP), and STIP includes sufficient financial information for

demonstrating that projects in the metropolitan transportation plan, TIP, and STIP can be implemented using committed, available, or reasonably available revenue sources, with reasonable assurance that the federally supported transportation system is being adequately operated and maintained.

For the TIP and the STIP, financial constraint or fiscal constraint applies to each program year. Additionally, projects in air quality nonattainment and maintenance areas can be included in the first 2 years of the TIP and STIP only if funds are available or committed (23 CFR 450.104).

First Responder A person who is certified to provide medical care in emergencies before more highly trained medical personnel arrive on the scene

Fusion Center A mechanism to exchange information and intelligence, maximize resources, streamline operations, and improve the ability to fight crime and terrorism by merging data from a variety of sources.

In addition, fusion centers are a conduit for implementing portions of the National Criminal Intelligence Sharing Plan (26).

Goals Generalized statements that broadly relate the future of the physical environment and the condition of the system to values (8). (Note: added “future of the” and “condition of the system.”)

Goals are developed with a view to mitigate any existing operational issues and needs, and to help achieve the long-term vision. Goals also provide the framework for developing objectives (refer to Objectives).

Greenhouse Gases (GHG) Gases in the atmosphere that trap the Earth’s heat.

The most prevalent GHGs are carbon dioxide (CO₂) and water vapor. Other GHGs include methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. GHGs vary in their effectiveness at trapping the Earth’s heat—also known as their global warming potential (27).

Hard Shoulder Running The temporary use of the outside or inside paved shoulder as a travel lane.

Often hard shoulder running use is limited to the morning or evening peak periods when recurrent congestion most often occurs, increasing available capacity and decreasing congestion during these periods. In other instances, hard shoulder running may be a means to improve traffic flow in the general-purpose lanes during incidents and special events. In most cases, hard shoulder running is implemented in conjunction with speed harmonization and lane control systems under reduced travel speeds to address geometric design and operating constraints of shoulder use (4).

High-Occupancy Toll (HOT) Lanes A strategy allowing vehicles that do not meet occupancy restrictions established for a high-occupancy vehicle (HOV) lane to use it through payment of a toll.

In a historic context, pricing has typically been applied as a tool on HOV lanes to utilize existing capacity that is available either as a result of underuse or changes in available capacity,

such as widening the existing HOV facility or raising occupancy rules. The toll is set to ensure that the lane remains free flowing. In this way, HOT lanes give drivers the option to pay for reliable and time-saving travel or to continue to travel on the general-purpose freeway lanes (25).

Incident (Traffic Incident) An unplanned randomly occurring traffic event that adversely affects normal traffic operations..

This definition is based on the Traffic Management Data Dictionary (TMDD) as published by ITE and AASHTO. The TMDD distinguishes traffic incident conditions from planned activities such as roadwork or maintenance activities. Use of this definition can be significant when collecting data for traffic incident performance measures such as roadway and incident clearance time (28).

Incident Command System (ICS) A systematic tool used for the command, control, and coordination of emergency response. ICS allows agencies to work together using common terminology and operating procedures controlling personnel, facilities, equipment, and communications at a single incident scene. It facilitates a consistent response to any incident by employing a common organizational structure that can be expanded and contracted in a logical manner based on the level of required response (29).

ICS is typically considered part of the broader National Incident Management System (NIMS). ICS refers to the command and control protocol at the highway incident scene. NIMS covers the entire incident management process, including command structures like ICS as well as preparedness activities, resource management, and communications and information management. NIMS specifies an ICS organization consisting of five major functions:

- Command—provide on-scene management and control authority;
- Operations—direct incident tactical operations;
- Planning—prepare incident action plan and maintain situation and resources status;
- Logistics—provide services and support to the incident; and
- Finance and administration—track incident costs and account for reimbursements.

A sixth function, intelligence, is sometimes added to an ICS organization in response to the NIMS guideline that an ICS must establish a process for gathering, sharing, and managing incident-related information and intelligence (29). (See also National Incident Management System.)

Incident Management (Traffic Incident Management) The systematic, planned, and coordinated use of human, institutional, electrical, mechanical, and technical resources to reduce the duration and impact of incidents, and improve the safety of motorists, crash victims, and incident responders. These resources are also used to increase the operating efficiency, safety, and mobility of the surface transportation network by systematically reducing the time to detect and verify an incident occurrence, implementing the appropriate response, and safely clearing the incident while managing the affected flow until full capacity is restored (30). (See also Incident and Incident Command System.) (Note: Added “electrical” and replaced “highway” with “surface transportation network.”)

Integration To make into a whole by bringing all parts together; unite (31).

A term that is used to describe a bridging function between all of the various components, activities, and related attributes that comprise and impact the surface transportation network. The goal of integration is to bring the management and operation of the surface transportation network into a unified whole, thereby making the various transportation modes and facilities perform better and work together (16).

Institutional Integration Coordination among various agencies and jurisdictions to achieve seamless operations or interoperability.

In order to achieve effective institutional integration of systems, agencies and jurisdictions must agree on the benefits of ITS and the value of being part of an integrated system. They must agree on roles, responsibilities, and shared operational strategies. Finally, they must agree on standards and, in some cases, technologies and operating procedures to ensure interoperability. The transportation agencies must also coordinate with agencies for which transportation is a key, but not a primary part of their business, such as emergency management and law enforcement agencies (32).

Institutional integration involves the coordination and collaboration between various agencies and jurisdictions (network owners) in support of Integrated Corridor Management (or Regional Transportation Systems Management and Operations), including establishing corridor or regionwide measures of performance, the distribution of specific operational responsibilities, and the sharing of control functions in a manner that transcends institutional boundaries (22). (Note: Added “Regional Transportation Systems Management and Operations” and “establishing corridor or regionwide measures of performance.”)

Integrated Corridor Management (ICM) ICM consists of the operational coordination of multiple transportation networks and cross-network connections comprising a corridor and the coordination of institutions responsible for corridor mobility. The goal of ICM is to improve mobility, safety, and other transportation objectives for travelers and goods.

ICM may encompass several activities, such as cooperative and integrated policy among stakeholders; concept of operations for corridor management; communications among network operators and stakeholders; improving the efficiency of cross-network junctions and interfaces; mobility opportunities including shifts to alternate routes and modes; real-time traffic and transit monitoring; real-time information distribution (including alternate networks); congestion management (recurring and nonrecurring); incident management; travel demand management; public awareness programs; transportation pricing and payment; access management; and growth management. ICM may result in the deployment of an actual transportation management system connecting the individual network-based transportation management systems; or integrated corridor management may just be a set of operational procedures, agreed to by the network owners, with appropriate linkages between their respective systems (21). (Note: Added “access management, and growth management.”)

Integrated Transportation Management System (ITMS). Provides for the automated, real-time sharing of information among ITS-based systems and the coordination of management activities among agencies.

An ITMS enhances system interoperability and enables an areawide view of the transportation network (33).

Intelligent Transportation System (ITS) The application of advanced electronics, computers, communications, and sensor technologies—in an integrated manner—to increase the efficiency and safety of the surface transportation network (34).

ITS improves transportation safety and mobility and enhances productivity through the use of advanced information and communications technologies.

ITS encompass a broad range of wireless and wire line communications-based information and electronics technologies. When integrated into the transportation system's infrastructure, and in vehicles themselves, these technologies relieve congestion, improve safety, and enhance productivity (8).

Intermodal The ability to connect, and the connections between, modes of transportation (8).

Interoperability The ability of two or more systems or components to exchange information and to use the information that has been exchanged (35).

The term is frequently used in the context of public safety communications and Dedicated Short Range Communications (DSRC). For example:

- It is critical that transportation agency communications systems be interoperable with those of the other responders with whom they will be working at incident scenes. Interoperability is an important issue for law enforcement, fire fighting, emergency services, and other public health and safety departments, because first responders need to be able to communicate during widescale emergencies. The nation's lack of interoperability in the public safety realm became evident during the September 11, 2001, attacks on the Pentagon and World Trade Center structures.

- Standards for DSRC are intended to meet the requirements of applications that depend upon transferring information between vehicles and roadside devices as well as between vehicles themselves. SAE J2735 (DSRC Message Set Dictionary) is to support interoperability among DSRC applications.

ITS Architecture A framework within which interrelated systems can be built that work together to deliver transportation services.

An ITS architecture defines a framework within which interrelated systems can be built that work together to deliver transportation services. It defines how systems functionally operate and the interconnection of information exchanges that must take place between these systems to accomplish transportation services (36). Combines definitions of architecture and ITS architecture.”

Junction Control A strategy that dynamically changes lane allocation at interchanges based on mainline and entering or exiting ramp volumes.

Junction control is useful for situations with a varying relationship between mainline demand and ramp demand. This strategy allows a ramp to have one or two lanes depending on the demand on the ramp and the mainline volume. Through use of signs (and possibly lighted pavement markers), junction control can close a mainline lane and create a second lane on the ramp for entering or exiting traffic. For entrance ramps, the right lane at the entrance would become an add lane by closing this lane to mainline traffic upstream of the ramp. For exit ramps, the right mainline lane approaching the ramp would become a drop lane. At other times of the

day, when ramp demand is not as high or when mainline volumes are such that a mainline lane can't be closed, the ramp would operate as a single lane and the right mainline lane would operate as a through lane through the interchange (4).

Livability Using the quality, location, and type of transportation facilities and services available to help achieve broader community goals. Livability in transportation helps to achieve those goals by leveraging financial resources and using the transportation planning process to advance supportive projects, policies, or decisions. Livability directly benefits people who live in, work in, or visit an area, whether in an urban, suburban, or rural context (37).

Livable Communities Places where transportation, housing, and commercial development investments are coordinated to better serve the people living in those communities (U.S. Department of Transportation–Housing and Urban Development Joint Grant Livability Program announcement).

Long-Range Transportation Plan (LRTP) A document resulting from regional or statewide collaboration and consensus on a region or state's transportation system, and serving as the defining vision for the region's or state's transportation systems and services.

Sometimes referred to as long-range plan (LRP), constrained LRP (CLRP), or regional transportation plan.

In metropolitan areas, the plan indicates all of the transportation improvements scheduled for funding over the next 20 years. It is fiscally constrained, i.e., a given program or project can reasonably expect to receive funding within the time allotted for its implementation (8).

Maintenance The preservation (scheduled and corrective) of infrastructure.

The preservation of the entire transportation infrastructure (e.g., highway, transit line), including surface, shoulders, roadsides, structures, and such traffic-control devices as are necessary for safe and efficient utilization of the highway–transit line. [23 U.S.C. 101(a)]. (Note: Added “transportation infrastructure” and “transit line.”)

Response maintenance involves actions performed on an as-needed basis (i.e., emergency maintenance); it is required when equipment breaks down or malfunctions.

Preventative maintenance involves actions performed on a regularly scheduled basis using a set of procedures to preserve the intended working condition of the system (38).

Managed Lanes Highway facilities or a set of lanes where operational strategies are proactively implemented and actively managed to optimize traffic flow and vehicular throughput.

Managed lanes are freeway lanes that are set aside and operated using a variety of fixed or real-time strategies responding to local goals and objectives that move traffic more efficiently in those lanes. As a result, travelers have options to traveling on a congested freeway. Managed lanes are typically differentiated and distinct from traditional freeway lanes because their operations can be actively managed and allowed to change over time in response to changing needs. A common element in the definitions is inclusion of a broad range of potential strategies and user groups (25). The principal management strategies can be categorized into three groups: pricing, vehicle eligibility, and access control (39).

Refer to HOV Lanes, HOT Lanes, and Express Toll Lanes.

Management The allocation of necessary resources for the proper functioning of the system (38). (See also Emergency Management, Incident Management, Integrated Corridor Management, and Special Event Management.)

Management and Operations Refer to Transportation Systems Management and Operations.

Metropolitan Planning Area The geographic area in which the metropolitan transportation planning process required by 23 USC 134 and Section 8 of the Federal Transit Act (49 USC app. 1607) must be carried out (8).

Metropolitan Planning Organization (MPO) The forum for cooperative transportation decision making for the metropolitan transportation planning area (23 CFR 972.104).

A regional planning body, required in urbanized areas with a population over 50,000, and designated by local officials and the governor of the state. It is responsible, in cooperation with the state and other transportation providers, for carrying out the metropolitan transportation planning requirements of federal highway and transit legislation. Formed in cooperation with the state, it develops transportation plans and programs for the metropolitan area. For each urbanized area, a MPO must be designated by agreement between the governor and local units of government representing 75% of the affected population (in the metropolitan area), including the central city or cities as defined by the Bureau of Census, or in accordance with procedures established by applicable state or local law [23 USC 134(b) (1) and Federal Transit Act of 1991 Sec. 8 (b) (1)].

Metropolitan Transportation Plan (MTP) The official multimodal transportation plan addressing no less than a 20-year planning horizon that is developed, adopted, and updated by the MPO through the metropolitan transportation planning process (23 CFR 450.104).

The plan shall include both long-range and short-range strategies and actions that lead to the development of an integrated intermodal transportation system that facilitates the efficient movement of people and goods. The transportation plan shall be reviewed and updated at least triennially in nonattainment and maintenance areas and at least every 5 years in attainment areas to confirm its validity and consistency with current and forecasted transportation and land use conditions and trends and to extend the forecast period (23 CFR 450.322).

The following factors shall be explicitly considered, analyzed as appropriate, and reflected in the metropolitan transportation planning process products:

1. Preservation of existing transportation facilities and, where practical, ways to meet transportation needs by using existing transportation facilities more efficiently;
2. Consistency of transportation planning with applicable federal, state, and local energy conservation programs, goals, and objectives;
3. The need to relieve congestion and prevent congestion from occurring where it does not yet occur;
4. The likely effect of transportation policy decisions on land use and development and the consistency of transportation plans and programs with the provisions of all applicable short- and long-term land use and development plans;
5. Programming of expenditures for transportation enhancement activities;

6. The effects of all transportation projects to be undertaken within the metropolitan planning area, without regard to the source of funding;
7. International border crossings and access to ports, airports, intermodal transportation facilities, major freight distribution routes, national parks, recreation areas, monuments and historic sites, and military installations;
8. Connectivity of roads within metropolitan planning areas with roads outside of those areas;
9. Transportation needs identified through the use of the management systems;
10. Preservation of rights-of-way for construction of future transportation projects, including future transportation corridors;
11. Enhancement of the efficient movement of freight;
12. The use of life-cycle costs in the design and engineering of bridges, tunnels, or pavement (operating and maintenance costs must be considered in analyzing transportation alternatives);
13. The overall social, economic, energy, and environmental effects of transportation decisions;
14. Expansion, enhancement, and increased use of transit services;
15. Capital investments that would result in increased security in transit systems; and
16. Recreational travel and tourism.

In addition, the metropolitan transportation planning process shall include a proactive public involvement process that provides complete information, timely public notice, full public access to key decisions, and supports early and continuing involvement of the public in developing plans (23 CFR 450.316).

Mileage-Based User Fee (MBUF) A fixed fee levied on each mile driven per vehicle within an implementing jurisdiction (40).

MBUF may address many of the long-term threats facing the fuel tax, mainly in that

- Revenues from a mileage-based fee system would not erode as vehicular fuel efficiencies increase;
- Revenues can be captured from vehicles that do not require fossil fuels to operate; and
- They are tied directly to use and can be structured to send appropriate market signals to drivers so as to maximize the efficient use of the roadway system.

Mobility The ability to move or be moved from place to place (8).

Mobility is at the heart of America's culture. Americans love the freedom of easily moving where they want, when they want. Mobility is at the heart of our economy, getting goods to market and getting people to work. Infrastructure—roads, bridges, and tunnels—provides the foundation that makes mobility possible (FHA Fact Sheet, Infrastructure: Providing for America's Mobility).

Multimodal The availability of transportation options using different modes within a system or corridor (8).

National ITS Architecture A common framework for ITS interoperability that defines (a) the functions associated with ITS user services; (b) the physical entities or subsystems within which the functions reside; (c) the data interfaces and information flows between physical subsystems; and (d) the communications requirements associated with the information flows (SAFETEA-LU Section 5310).

The National ITS Architecture is maintained by the U.S. DOT and is available on the DOT website at <http://www.its.dot.gov>.

National Incident Management System (NIMS) A unified national framework for incident management, providing a consistent nationwide approach for federal, state, local, and tribal governments, the private sector, and nongovernmental organizations to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity.

NIMS includes a core set of concepts, principles, and terminology, identified as the ICS; multiagency coordination systems; training; identification and management of resources; qualification and certification; and the collection, tracking, and reporting of incident information and incident resources (41). (Refer to Incident Command System.)

Next Generation 9-1-1 (NexGen911) A research and development project to help define the system architecture and develop a transition plan to establish a digital, Internet protocol-based foundation for the delivery of multimedia 9-1-1 calls (42, 43).

Objectives Specific, measurable statements related to the attainment of goals (9).

The differences between goals (refer to definition in this glossary) and objectives may be summarized as follows:

- Goals are broad; objectives are narrow.
- Goals are general intentions; objectives are precise.
- Goals are intangible; objectives are tangible.
- Goals are abstract; objectives are concrete.
- Goals can't be validated as is; objectives can be validated.

Operational Concept The roles and responsibilities of the primary stakeholders and the systems they operate (14). (Also refer to Concept of Operations.)

The purposes of an occupational concept document (OCD) are to

- Describe the system characteristics from an operational perspective;
- Facilitate understanding of the overall system goals with users, buyer, implementers, architects, testers, and managers;
 - Form an overall basis for long-range operations planning and provide guidance for development of subsequent system definition documents such as system specification and interface specifications; and
 - Describe the users organization and mission from and integrated user/system point of view.

The OCD must be somewhat all things to all people because the intended audience has a wide range of technical and managerial backgrounds. At the same time it must be readable and understandable. The most practical way to achieve this goal is to write the OCD in a narrative form describing, in nonspecification-type prose, the way in which the system is envisioned to fit and function within the proposed or expected operational environment. A good OCD should tell a story; that is, it should be a narrative, pictorial description of the system's intended use. This is accomplished by describing the what, where, when, who, why, and how of the system operations (44).

Operational Integration The implementation of multi-agency transportation management strategies, often in real time, that promote information sharing and cross-network coordination and operations among the various transportation networks in the corridor–regions, and facilitate management of the total capacity and demand of the corridor–region (21). (Note: Added the term “region.”)

Operations All decision making and actions necessary for the proper functioning of a system, such as information gathering (from a variety of sources), synthesis and processing, and dissemination and distribution of the decisions and information to traffic control equipment, other agencies and decision makers (including those associated with maintenance activities), and the public (38). (Also see Transportation Systems Management and Operations.) (Note: Added the context of “decision making” and “decision makers.”)

This is done in anticipation of, or in response to, both recurring and nonrecurring conditions. Operations includes a range of activities in both urban and rural environments, including: routine traffic and transit operations, public safety responses, incident management, snow and ice management, network–facility management, planned construction disruptions, and traveler–shipper information (11).

Performance Measurement A process of assessing progress toward achieving predetermined goals.

Performance measurement is a process of assessing progress toward achieving predetermined goals, including information on the efficiency with which resources are transformed into goods and services, the quality of those outputs (how well they are delivered to clients and the extent to which clients are satisfied) and outcomes (the results of a program activity compared to its intended purpose), and the effectiveness of government operations in terms of their specific contribution to program objectives (45).

Performance measurement supports the decision making process by generating indicators of how well the transportation system is achieving the desired or expected outcomes (11).

Performance Measures Indicators that provide the basis for evaluating the transportation system operating conditions and identifying the location and severity of congestion and other problems.

Performance measures provide the basis for evaluating the transportation system operating conditions and identifying the location and severity of congestion and other problems. The performance measures provide the mechanism for quantifying the operation of the network, and should also be used to evaluate the effectiveness of implemented transportation management strategies and to identify additional improvements. Another aspect of performance measurement

is sharing and providing managers and users with access to real-time and archived system performance data (46).

Performance measures are often described as input, output, or outcome measures. Input measures look at the resources dedicated to a program; output measures look at the products produced; and outcome measures look at the impact of the products on the goals of the agency. For example, with respect to increasing roadway capacity, an input measure might be materials consumed; output measures could include lane miles added, while an outcome measure might include the reduction in hours of user delay, resulting from the increased capacity (47).

ICM and regional transportation systems management and operations (RTSMO) requires performance measures that are mode neutral, reflecting overall corridor–regional mobility and reliability (e.g., person based or trip based utilizing travel times and delays). Moreover, three dimensions of corridor–regional operations should be tracked with performance measures: source of congestion–problem, temporal aspects, and spatial detail. Customer satisfaction measures should also be considered. It is emphasized that these corridor–regionwide performance measures are in addition to any network-specific performance measures. As such, the relationship between the corridor–regional performance measures and network-specific measures need to be addressed (21). (Note: Added the term “region” and “RTSMO.”)

Planned Special Event A public activity with a scheduled time, location, and duration that may impact the normal operation of the surface transportation system due to increased travel demand or reduced capacity because of event staging (48).

Planned Special Event Management Developing and implementing a transportation management plan that contains operations and service strategies specific to managing traffic, transit, and travel demand for a planned special event.

The goals of planned special event management include achieving predictability (e.g., define the area and transportation system components impacted, conduct analyses of parking demand and traffic demand), ensuring safety (e.g., minimize pedestrian–vehicular conflicts, provide unimpeded access routes for emergency services), and maximizing efficiency (e.g., use all available resources and excess transportation system capacity, including road and transit capacity) (48).

Planning Factors A set of broad objectives defined in federal legislation to be considered in both the metropolitan and statewide planning process.

Planning factors are a set of broad objectives defined in federal legislation to be considered in both the metropolitan and statewide planning process. Both SAFETEA-LU and its predecessors, Transportation Equity Act for the 21st Century (TEA-21) and the Intermodal Surface Transportation Efficiency act of 1991, identify specific factors that must be considered in the planning process. TEA-21 consolidated what were previously 16 metropolitan and 23 statewide planning factors into seven broad areas to be considered in the planning process, both at the metropolitan and statewide level. SAFETEA-LU increased the number of planning factors to eight by creating separate planning factors for safety and security. SAFETEA-LU added language to emphasize the correspondence between transportation improvements and economic development and growth plans. The planning factors are as follows [SAFETEA-LU Section 6001(a) and 23 U.S.C. 134 (h) (1)]:

- Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity, and efficiency;
- Increase the safety of the transportation system for motorized and nonmotorized users;
- Increase the security of the transportation system for motorized and nonmotorized users;
- Increase the accessibility and mobility of people and for freight;
- Protect and enhance the environment, promote energy conservation, improve the quality of life, and promote consistency between transportation improvements and state and local planned growth and economic development patterns;
- Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight;
- Promote efficient system management and operation; and
- Emphasize the preservation of the existing transportation system.

Planning for Operations A set of activities that takes place within the context of an agency, jurisdiction, or regional entity with the intent of establishing and carrying out plans, policies, and procedures that enable and improve the management and operation of transportation systems (11).

Planning for operations is a joint effort between operations and planning that encompasses the important institutional underpinnings needed for effective regional transportation systems management and operations. Planning for operations includes three important aspects:

1. Regional transportation operations collaboration and coordination activity that facilitates regional transportation systems management and operations;
2. Management and operations considerations within the context of the ongoing regional transportation planning and investment process; and
3. The opportunities for linkage between regional operations collaboration and regional planning.

Procedural Integration The legislative, policy, planning, programming, and budgeting environment in which the transportation infrastructure functions.

Management and operations and the associated technical, operational, and institutional integration requires that those in authority make decisions to pursue integration of the surface transportation network and then support this integration by providing the necessary resources. Decision making is aided by a variety of procedures and processes, both formal and informal (46).

Program A coordinated, interrelated set of strategies, procedures, and activities, all intended to meet the goals and objectives articulated in vision statements and policies.

A program has a long-term temporal view, whereas individual projects (refer to definition below) generally have a shorter implementation period. Managing a program involves trade-offs between budget and timing, and determinations as to appropriate sequence and scope of the associated projects (46).

Project Well-defined, individual actions and activities that make up a program. The implementation of projects is how the program is realized (46).

Queue Warning The use of technologies (e.g., warning signs, flashing lights, in-vehicle devices) to alert motorists of downstream queues.

Queue warning goals include effectively utilizing available roadway capacity and reducing the likelihood of collisions related to queuing. In some applications, the cause of the queue (crash, maintenance activities, other congestion) is also displayed on dynamic message signs (49).

Ramp Management The application of control devices, such as traffic signals, signing, and gates to regulate the number of vehicles entering or leaving the freeway, or to smooth out the rate at which vehicles enter and exit the freeway. Ramp management is implemented to achieve operational objectives such as: improved safety, improved mobility, improved perception of transportation management agencies and staff, and reduced environmental impacts.

Ramp management typically encompasses the following strategies (16):

- *Ramp metering*—the use of a traffic signal deployed on a ramp to control the rate at which vehicles enter a freeway. By controlling the rate at which vehicles are allowed to enter a freeway, the flow of traffic onto the freeway becomes more consistent, smoothing the flow of traffic on the mainline and allowing more efficient use of existing freeway capacity.
- *Ramp closure*.
- *Special use treatments*—giving special consideration to a vehicle class or classes to improve safety, improve traffic conditions, and encourage specific types of driving behavior. Examples include HOV bypass lanes and HOV exclusive ramps.
- *Ramp terminal treatments*—typically focused on managing queues that form on the ramp and spill back onto an adjacent arterial or the freeway facility. Examples include ramp widening to provide additional storage or special-purpose lanes, signal timing and turn restrictions upstream of the ramp, and signing and pavement marking improvements.

Region Metropolitan or any other multi-jurisdictional area (11).

In the context of ITS, a region is the geographical area that identifies the boundaries of the regional ITS architecture and is defined by and based on the needs of the participating agencies and other stakeholders. In metropolitan areas, a region should be no less than the boundaries of the metropolitan planning area (23 CFR Part 940.3).

For the purposes of an regional concept for transportation operations, a region is considered to be any multijurisdictional area defined by the collaborative partners. That area may or may not coincide with the boundaries of a MPO (50).

Regional Concept for Transportation Operations (RCTO) A framework that guides collaborative efforts to improve system performance through management and operations strategies. The RCTO is a management tool to assist in planning and implementing these strategies (within a region) in a collaborative and sustained manner (50). (Note: Added “within a region.”)

The RCTO promotes a more systemic and sustained approach to collaboration. Consistent with well-established systems engineering principles, the RCTO elevates the focus from agencies’ individual responsibilities to a global view of the region’s transportation system.

Developing an RCTO helps partnering agencies think through and reach consensus on what they want to achieve in the next 3 to 5 years and how they are going to get there.

The scope of an RCTO is defined in terms of three major dimensions: functional, institutional, and geographic. The functional dimension defines the operations areas addressed within the RCTO; the institutional dimension defines the partnering entities engaged in the developing and carrying out the RCTO; and the geographic dimension defines the region (i.e., political boundaries) for which the RCTO is developed. Each dimension is shaped by the collaborative activity among transportation operators from multiple jurisdictions (50).

Regional ITS Architecture A regional framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects (23 CFR Part 940.3).

The regional ITS architecture shall include, at a minimum, the following (23 CFR Part 940.9):

1. A description of the region;
2. Identification of participating agencies and other stakeholders;
3. An operational concept that identifies the roles and responsibilities of participating agencies and stakeholders in the operation and implementation of the systems included in the regional ITS architecture;
4. Any agreements (existing or new) required for operations, including at a minimum those affecting ITS project interoperability, utilization of ITS related standards, and the operation of the projects identified in the regional ITS architecture;
5. System functional requirements;
6. Interface requirements and information exchanges with planned and existing systems and subsystems (for example, subsystems and architecture flows as defined in the National ITS Architecture);
7. Identification of ITS standards supporting regional and national interoperability; and
8. The sequence of projects required for implementation.

Development of the regional ITS architecture should be consistent with the transportation planning process for statewide and metropolitan transportation planning (23 CFR Part 940.5).

Regional Planning Organization (RPO) An organization that performs planning for multijurisdictional areas. MPOs, regional councils, economic development associations, rural transportation associations are examples of RPOs (8).

Regional Transportation System Management and Operations (RTSMO) An integrated program to optimize the performance of the existing infrastructure through implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of transportation systems.

Examples of programs and project areas where RTSMO can be implemented include (but not limited to) active transportation and demand management (ATDM) and the associated strategies, emergency management, incident management, road weather management, special events management, managed lanes, work zone management, demand

management, congestion pricing, and integrated corridor management (11). (Refer to definitions in this glossary.) (Note: Added “ATDM” as an example.)

Examples of programs and project areas where RTSMO can be implemented include (but not limited to) emergency management, incident management, road weather management, special events management, managed lanes, work zone management, demand management, congestion pricing, and integrated corridor management (11). (Refer to definitions in this glossary).

RTSMO requires regional transportation operations collaboration and coordination—a deliberate, continuous, and sustained activity that takes place when transportation agency managers and officials responsible for day-to-day operations (i.e., stakeholders) work together at a regional level to solve operational problems, improve system performance, and communicate better with one another (51). (Note: Added “stakeholders.” Refer to definition of Stakeholder.)

Reliability The degree of certainty and predictability in travel times on the transportation system. Reliable transportation systems offer some assurance of attaining a given destination within a reasonable range of an expected time. An unreliable transportation system is subject to unexpected delays, increasing costs for system users (52).

A related performance measure is that of travel time reliability, defined as the consistency or dependability in travel times, as measured from day-to-day or across different times of the day (53).

Road Pricing A fee related to the use of a roadway facility. Road pricing may impose a price on a vehicle’s use of the road based on time of day, location, type of vehicle, number of occupants, or other factors (54). Also refer to Mileage-Based User Fee.

Road Weather Management Mitigation strategies employed in response to various weather threats including fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.

Three types of road weather management strategies may be employed in response to environmental threats: advisory, control, and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies (55).

Stakeholder Person or group affected by a transportation plan, program or project. Person or group believing that they are affected by a transportation plan, program, or project. Residents of affected geographical areas (8).

Stakeholders include any person or group with a direct interest (a “stake” as it were) in the integrated operation of the corridor–region and the associated networks and cross-network linkages. Stakeholders are sources of the corridor–regional vision, goals, and objectives, operational approaches and strategies, and requirements (21).

State Transportation Improvement Program (STIP) A statewide prioritized listing or program of transportation projects covering a period of 4 years.

Must be consistent with the long-range statewide transportation plan, MPO plans, and TIPs; required for projects to be eligible for funding under title 23 USC and title 49 USC Chapter 53 (23 CFR 450.104).

Sustainable Transportation (Sustainability) Meeting, and sometimes redefining, the mobility needs of the present without compromising the ability of future generations to meet their needs.

There are several attributes associated with a sustainable transportation network—a three-dimensional framework consisting of economic, social, and environmental considerations (56).

- *Economic*—Transportation has long been recognized as essential to economic development. Efficient and reliable movement of people and goods, that is, mobility, improves productivity and can spur economic growth.
- *Social*—People who are economically, socially, or physically disadvantaged need transportation options and choices to give them opportunities to work, learn, and participate in society. Related societal issues include the security and the safety of the transportation network.
- *Environmental*—On a global scale, the looming threat of climate change has focused attention on the environmental impacts of the transportation sector, which contributes more than 25% of our nation’s GHG emissions.

Sustainability must be viewed as a collective process where decision making and actions carefully evaluate and balance the potential impacts of this “triple bottom line” (56).

Systems Engineering A process incorporating a set of management and technical tools to analyze problems and provide structure to projects involving system development. A requirements-driven process in which user requirements are the overriding determinant of system design, component selection, and implementation.

Systems engineering focuses on ensuring that requirements are adequately defined early in the process and that the system built satisfies all defined requirements. It ensures that systems are robust yet sufficiently flexible to meet a reasonable set of changing needs during the system’s life. It helps manage projects to their cost and schedule constraints and keeps realism in project cost and schedule estimates.”

Systems engineering helps accomplish four key activities that impact a project’s success: identify and evaluate alternatives; manage uncertainty and risk in our systems; design quality into our systems; and handle program management issues that arise (13).

Technical Integration Provides the means (e.g., communication links between agencies, system interfaces, and the associated standards) by which information and system operations and control functions can be effectively shared and distributed among networks and their respective transportation management systems, and by which the impacts of operational decisions can be immediately viewed and evaluated by the affected agencies (21).

3-C Process Continuing, cooperative, and comprehensive planning process. A continuing, cooperative, and comprehensive process to encourage and promote the development of a multimodal transportation system that ensures safe and efficient movement of people and goods

while balancing environmental and community needs. Statewide and metropolitan transportation planning processes are governed by federal law and applicable state and local laws (57).

Traffic Incident Refer to definition of Incident.

Traffic Management Channel (TMC) A specific application of the FM Radio Data System (RDS) used for broadcasting real-time traffic and weather information

Standard TMC user messages provide five basic items of broadcast information:

- Event description, details of the weather situation, or traffic problem and its severity.
- Location, the area, highway segment, or point location affected.
- Direction and extent, identifying the adjacent segments or point locations affected, and the direction of traffic affected.
- Duration, how long the problem is expected to last.
- Diversion advice, whether or not drivers are advised to find an alternative route.

TMC traffic data are already being broadcast in several countries in Europe (58). (Note: In North America, TMC location codes are assigned and maintained through a collaborative effort between map publishers NAVTEQ and TeleAtlas. The network segments used by most information service providers in the United States are based on these TMC codes in order to standardize the reporting of traffic events on major roadways under a unique set of geographical references. TMC codes are typically assigned at significant decision points and intersections.)

Traffic Signal Management The planning, design, integration, maintenance, and proactive management of a traffic signal system in order to achieve policy based objectives to improve the efficiency, consistency, safety, and reliability of the traffic signal system.

Traffic Signal Management includes the design and maintenance of timing parameters for the traffic conditions as well as the maintenance of the equipment. Traffic signal systems include a wide variety of subsystems, such as traffic signal displays, traffic signal controllers, detection systems, data collection and archiving, surveillance and monitoring, and telecommunications. By extending this across jurisdictional boundaries and cooperating among agencies (i.e., Regional Traffic Signal Management), there can be effective collaboration to improve service quality by sharing experiences and planning to address future needs (59).

Transit Signal Priority (TSP) An operational strategy that facilitates the movement of transit vehicles, either buses or streetcars, through traffic-signal controlled intersections. Objectives of TSP include improved schedule adherence and improved transit travel time efficiency while minimizing impacts to normal traffic operations e trips by providing travelers with choices relative to route, time, and mode.

TSP is made up of four components (60): (a) a detection system that lets the TSP system “know” where the vehicle requesting signal priority is located. This may include a GPS system onboard the bus and other information such as the vehicle’s current schedule adherence and current passenger count. The detection system communicates with a (b) priority request generator that alerts the upstream signal–traffic control system that the vehicle would like to receive priority. There is central software or local firmware that processes the request and decides whether and how to grant priority based on the programmed (c) priority control

strategies. And there is software that (*d*) manages the system, collects data, and generates reports. Priority may involve extending the green phase for the transit vehicle, early green, phase rotation or skipping, or queue jumping. TSP maintains all minimum times to ensure motorist and pedestrian safety.

Transportation Asset Management (TAM) A strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively through their life cycle. It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well-defined objectives (AASHTO's Subcommittee on Asset Management.)

The goal of a TAM program is to minimize the life-cycle costs for managing and maintaining transportation assets, including roads, bridges, tunnels, rails, and roadside features. TAM principles and techniques should be applied throughout the planning process, from initial goal setting and long-range planning to development of a TIP and STIP and then through to operations, preservation, and maintenance (*61*).

Transportation Demand Management (TDM) Programs designed to reduce vehicle demand on the transportation system during the peak hours through various means, such as the use of transit and of alternative work hours (*12*). (Note: Added "vehicle" and "during the peak hours.")

In the broadest sense, transportation demand management (TDM) is any action or set of actions intended to influence the intensity, timing, and spatial distribution of transportation demand for the purpose of reducing the impact of traffic or enhancing mobility options (*12*).

Transportation Improvement Program (TIP) A prioritized listing or program of transportation projects covering a period of 4 years that is developed and formally adopted by an MPO as part of the metropolitan transportation planning process.

Must be consistent with the metropolitan transportation plan; required for projects to be eligible for funding under title 23 USC and title 49 USC Chapter 53 (23 CFR 450.104).

Transportation Management Area (TMA) An urbanized area with a population over 200,000, as defined by the Bureau of Census and designated by the Secretary of Transportation, or any additional area where TMA designation is requested by the Governor and the MPO and designated by the Secretary of Transportation (23 CFR 450.104).

Transportation Management Center (TMC) The hub of a transportation management and control system. The TMC brings together human and technological components from various agencies to perform a variety of functions.

TMCs may deal with freeway traffic management, surface street traffic management, transit management or some combination of these functions (*62*).

Transportation Systems Management and Operations (TSM&O) An integrated program to optimize the performance of existing infrastructure through the implementation of systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system.

The term includes regional operations collaboration and coordination activities between transportation and public safety agencies and improvements to the transportation system such as

traffic detection and surveillance, arterial management, freeway management, demand management, work zone management, emergency management, electronic toll collection, automated enforcement, traffic incident management, roadway weather management, traveler information services, commercial vehicle operations, traffic control, freight management, and coordination of highway, rail, transit, bicycle, and pedestrian operations (12).

Travel Demand Management Managing both the growth of and periodic shifts in traffic demand in a manner that optimizes transportation system performance for commute and non-commute trips by providing travelers with choices relative to route, time, and mode.

Managing demand can no longer stop at encouraging travelers to change their travel mode from driving alone to choosing a carpool, vanpool, public transit vehicle, or other commuter alternative. Managing demand today is about providing all travelers, regardless of whether they drive alone, with choices of location, route, and time, not just mode of travel. Real-time information systems can now let travelers make better decisions about how they travel (mode), when they travel (time), where and whether they travel (location), and which route they travel (path) (63). (Also refer to ATDM and Travel Time Signing and Dynamic Rerouting.)

Travel Time Signing An approach that uses specially designed variable message signs to display estimated travel time information to drivers of a roadway facility.

Travel time information may also be posted to online travel sites to assist motorists in making travel-related decisions prior to making the trip. This information can be used by travelers prior to leaving their destination as well as when en route, providing the ability to choose alternate routes and reduce stress and anxiety associated with congested conditions and variable travel times. Because specific routes are posted on travel time signs, it is expected that nonlocal travelers will not feel as comfortable changing from primary travel routes. In contrast, local travelers will obtain a greater benefit from travel time signing because they are more familiar with alternate routes (5).

Unified Planning Work Program (UPWP) A statement of work identifying the planning priorities and activities to be carried out within a metropolitan planning area.

At a minimum, the UPWP includes a description of the planning work and resulting products, who will perform the work, time frames for completing the work, the cost of the work, and the source of funds (23 CFR 450.104).

Variable Speed Displays Variable speed displays are set (and varied) according to prevalent roadway and operating conditions, including visibility, weather, lane constraints (e.g., work zones), incidents, and real-time traffic flows—congestion levels. This helps minimize the differences between the lowest and highest vehicle speeds. The deployment of this ATM strategy is proactive and automated to optimize its benefits.

Variable speed displays may be advisory or regulatory. If they are regulatory (i.e., variable speed limits), they are legal speed limits for which a motorist can receive a citation if they exceed the posted limit. If they are advisory, a motorist cannot be cited for a speed limit violation unless in the officer's judgment they are driving too fast for the prevailing conditions.

The intent of these variable speed systems—often used in conjunction with Dynamic Lane Assignment (refer to definition in this glossary)—is to regulate the speeds or advise motorists of downstream conditions, incidents, or congestion—providing advance warning to

motorists and the need to reduce speeds prior to an incident or congestion, and the ability to merge out of lanes that are closed downstream in an orderly manner. Additionally, by stabilizing traffic speeds, variable speed displays and lane control systems work to reduce flow breakdown and the onset of stop-and-go driving behavior. This results in more uniform traffic flow and safer driving conditions and reduces both primary and secondary incidents and their severity (5).

Vision An agreed statement of the overall aims of a transportation plan.

In the context of regional transportation, a vision is the regionally agreed statement of the overall aims of the regional transportation plan and describes the target end state. Typically, a regional transportation vision will drive its goals (policy statements in which the ends toward which effort is directed), objectives (measurable results), and strategies (ways or means to achieve objectives) (12).

The purpose of a vision statement is to portray the future system and its operation for a specific time horizon, providing a platform for establishing goals and objectives. The vision statement must also be simple, easy to read and accessible to a wide audience (22).

Work Zone An area of highway or transit line with construction, maintenance, or utility work activities.

A work zone is typically marked by signs, channelizing devices, barriers, pavement markings, or work vehicles (12). (Note: Added “transit line.”)

Work Zone Management Strategies implemented for managing traffic during construction as necessary to minimize traffic delays, maintain or improve motorist and worker safety, complete roadwork in a timely manner, and maintain access for businesses and residents.

Transportation management strategies for a work zone include temporary traffic control measures and devices, public information and outreach, and operational strategies such as travel demand management, signal retiming, and traffic incident management (64).

References

1. *Access Management Manual*. Transportation Research Board of the National Academies, Washington, D.C., 2003.
2. Levinson, D. M., and E. Istrate. *Access for Value: Financing Transportation Through Land Value Capture*. The Brookings Institute, 2011.
3. *Active Traffic Management: The Next Step in Congestion Management*. FHWA-PL-07-012. FHWA, U.S. Department of Transportation, July 2007.
4. *Active Transportation and Demand Management: White Paper—Draft*. Prepared for FHWA for the Active Traffic Management Program—Technical Assistance and Support, October 2010.
5. *Special Report 290: Potential Impacts of Climate Change on U.S. Transportation*. Transportation Research Board of the National Academies, Washington, D.C., 2008.
6. Federal Transit Administration. <http://www.fta.dot.gov/assistance/technology/research>.
7. *What Is BRT?* National BRT Institute, 2009. Available at <http://www.nbrti.org/>.
8. *Transportation Planning Capacity Building Glossary*. FHWA, U.S. Department of Transportation. Available at <http://www.planning.dot.gov/glossary.asp>.
9. *TCRP Report 100: Transit Capacity and Quality of Service Manual, 2nd Edition*. Transportation Research Board of the National Academies, Washington, D.C., 2003.
10. <http://www.clarusinitiative.org/background.htm>.
11. *Planning for Operations—Glossary*. Available at <http://plan4operations.dot.gov/glossary.htm>.
12. *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*. FHWA-OP-03-008. FHWA, U.S. Department of Transportation, 2002.
13. *Building Quality Intelligent Transportation Systems Through Systems Engineering*. FHWA, U.S. Department of Transportation, April 2002.
14. *Systems Engineering Guidebook for Intelligent Transportation Systems*. Caltrans and Federal Highway Administration, 2009. Available at <http://www.fhwa.dot.gov/cadiv/segb/>.
15. *NCHRP Report 398: Quantifying Congestion*. TRB, National Research Council, Washington, D.C., 1997.
16. *Freeway Management and Operations Handbook*. FHWA-OP-04-003. FHWA, U.S. Department of Transportation, March 2006.
17. *Congestion Management Process: A Guidebook*. FHWA, U.S. Department of Transportation, April 2011.
18. *Congestion Pricing: A Primer*. FHWA, U.S. Department of Transportation, December 2006.
19. http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm.
20. http://www.fhwa.dot.gov/context/css_primer/whatis.htm.
21. *Integrated Corridor Management (ICM) Implementation Guidance*. FHWA-JPO-06-042/EDL #14284. FHWA, U.S. Department of Transportation, April 2006.
22. *Guidelines for Developing ITS Data Archiving Systems*. Report 2127-3. Texas Transportation Institute, College Station, September 2001.
23. FHWA Office of Operations/Emergency Management website: <http://www.ops.fhwa.dot.gov/OpsSecurity>.
24. *ETO Strategic Plan*. New York State Department of Transportation.
25. Managed Lane Chapter. *Freeway Management and Operations Handbook*, 2011.
26. <http://www.it.ojp.gov/default.aspx?area=nationalInitiatives&page=1181>.
27. *Primer on Transportation and Climate Change*. AASHTO, April 2008.
28. Final Report. Recommendations for Improving the Use of Traffic Incident Management Performance Measures When Comparing Operations Performance Between State DOTs. NCHRP

- Project 20-24(37)D. Transportation Research Board of the National Academies, Washington, D.C., January 2011.
29. *Simplified Guide to the Incident Command System for Transportation Professionals*. FHWA-HOP-06-004. FHWA, U.S. Department of Transportation, 2006.
 30. *Traffic Incident Management Handbook*. EDL#13286. FHWA, U.S. Department of Transportation, November 2000.
 31. *American Heritage Dictionary*, 4th Edition.
 32. 23 CFR Parts 655 and 940, Supplementary Information. *Federal Register*.
 33. *Proc., 4th Integrated Transportation Management Systems (ITMS) Conference*. August 2001. Available at http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13661.pdf.
 34. *ITS America 10-Year Vision*.
 35. *IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries*. Institute of Electrical and Electronics Engineers.
 36. *Regional ITS Architecture Guidance—Developing, Using, and Maintaining an ITS Architecture for Your Region, Version 2.0*. U.S. Department of Transportation, July 6, 2006.
 37. Glossary from *Draft Sustainability and Livability Primer*. U.S. Department of Transportation, 2012.
 38. Kraft, W., and J. Giblin. *Traffic Control Systems Operations, Installation, Management, and Maintenance*. Institute of Transportation Engineers, 2000.
 39. *Managed Lanes: A Primer*. FHWA, U.S. Department of Transportation.
 40. *Mileage-Based User Fees: Defining a Path Toward Implementation*. University Transportation Center for Mobility, Texas Transportation Institute, College Station, 2009.
 41. National Incident Management System, U.S. Department of Homeland Security, March 2004.
 42. <http://www.fcc.gov/pshs/services/911-services/nextgen.html>.
 43. <http://www.its.dot.gov/ng911/index.htm>.
 44. *Guide for the Preparation of Operational Concept Documents*. American National Standards Institute.
 45. *NCHRP Synthesis of Highway Practice 311: Performance Measures of Operational Effectiveness for Highway Segments and Systems*. Transportation Research Board of the National Academies, Washington, D.C., 2003.
 46. *Freeway Management and Operations Handbook*. FHWA-OP-04-003. FHWA, U.S. Department of Transportation, September 2003.
 47. Dalton, D., J. Nestler, J. Nordbo, B. St. Clair, E. Wittwer, and M. Wolfgram. Transportation Data and Performance Measurement. In *Conference Proceedings 26: Performance Measures to Improve Transportation Systems and Agency Operations*, TRB, National Research Council, Washington, D.C., 2001, pp. 75–87.
 48. *Managing Travel for Planned Special Events*. FHWA-OP-04-010. FHWA, U.S. Department of Transportation, June 2007.
 49. *Synthesis of Active Traffic Management Experiences in Europe and the United States*. <http://www.ops.fhwa.dot.gov/publications/fhwahop10031/sec3.htm>.
 50. *Regional Concept for Transportation Operations—The Blueprint for Action*. FHWA-HOP-07-122. FHWA, U.S. Department of Transportation, June 2007.
 51. *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*. FHWA, U.S. Department of Transportation, 2003.
 52. *Planning Glossary*. FHWA, U.S. Department of Transportation. Available at <http://www.fhwa.dot.gov/planning/glossary/index.cfm>.
 53. http://ops.fhwa.dot.gov/perf_measurement/reliability_measures/index.htm.
 54. *Road Pricing Defined*. FHWA, U.S. Department of Transportation. Available at http://www.fhwa.dot.gov/ipd/revenue/road_pricing/defined/index.htm.
 55. *Best Practices for Road Weather Management, Version 2.0*. FHWA-OP-03-081. FHWA, U.S. Department of Transportation, May 2003.

56. Position Paper on Sustainable Transportation. ITS America, 2010.
57. *Transportation Planning Capacity Building Acronym List*. FHWA, U.S. Department of Transportation. Available at <http://www.planning.dot.gov/glossary.asp#acronyms>.
58. <http://www.tmcforum.com/en/home.htm>.
59. *Regional Traffic Signal Operations Programs: An Overview*. FHWA-HOP-09-007. FHWA, U.S. Department of Transportation, October 2009. Available at <http://ops.fhwa.dot.gov/publications/fhwahop09007/index.htm#s2>.
60. Smith, H. R., B. Hemily, and M. Ivanovic. *Transit Signal Priority: A Planning and Implementation Handbook*. ITS America and Federal Transit Administration, Washington, D.C., May 2005. Available at <http://www.fta.dot.gov/documents/TSPHandbook10-20-05.pdf>.
61. <http://www.fhwa.dot.gov/infrastructure/asstmgmt/tpamb.cfm>.
62. http://ops.fhwa.dot.gov/publications/fhwahop06006/chapter_8.htm.
63. FHWA Office of Operations website: Overview of Travel Demand Management.
64. http://ops.fhwa.dot.gov/wz/traffic_analysis/wztm.htm.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. www.TRB.org

www.national-academies.org



TRANSPORTATION RESEARCH BOARD
500 Fifth Street, NW
Washington, DC 20001

THE NATIONAL ACADEMIES™

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org